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ISCHNOPTERAPION (CHLORAPION) VIRENS (HERBST) (COLEOPTERA: CURCULIONOIDEA: BRENTIDAE: APIONINAE), A PALEARCTIC CLOVER PEST NEW TO NORTH AMERICA: RECOGNITION FEATURES, DISTRIBUTION, AND BIONOMICS

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Abstract.—*Ischnopterapion* (*Chlorapion*) *virens* (Herbst) is reported for the first time in North America based on collections in 22 counties in Pennsylvania, 5 counties in New York, 3 counties each in Maryland and New Jersey, and 1 county each in western Connecticut, northern Delaware, and northern Virginia. This immigrant weevil is a pest of clover (*Trifolium* spp.), with adults injuring the foliage, and larvae mining in the petioles, stems (stolons), root-crowns, and roots. A detailed redescription and a thorough diagnosis of the adult are given to allow its identification and separation from similar Nearctic species, and its biology and seasonal history in the Palearctic region are summarized from the European literature.

Key Words: *Ischnopterapion* (*Chlorapion*) *virens*, immigrant weevil, clover pest, systematics, bionomics

The first North American collections of the Palearctic apionine weevil *Ischnopterapion virens* (Herbst), a pest of clover, were made during an inventory to: (1) determine invertebrate species richness and abundance in dairy farm paddocks under different grazing regimes in the northeastern United States; and, (2) to identify invertebrate species that may potentially affect sustainability of pasture systems. Soil sampling for this invertebrate survey was conducted by RAB and Gary M. Barker (Agresearch, Hamilton, New Zealand) on 21 Pennsylvania farms from 1994–1996.

Most of the world's described taxa in the subfamily Apioninae[1] [currently placed in the Brentidae, see Kuschel (1995) and Lawrence and Newton (1995)] historically have been assigned to the exceptionally large and difficult genus *Apion*, which includes nearly 1,600 species. In America north of Mexico, more than 150 species of *Apion* have been recorded (O'Brien and Wibmer 1982). In this paper, we recognize the supraspecific taxa proposed by Alonso-Zarazaga (1990) in which many of the for-

[1] The classification presented in Kuschel (1995) and Lawrence and Newton (1995) is followed here, with the Apioninae recognized as a subfamily of the Brentidae (ERH).

mer subgenera of *Apion* are elevated to generic rank.

Here, we list and map the known distributional records of *I. virens* in the eastern United States; provide characters to identify this newly detected immigrant and to allow it to be distinguished from similar native apionine weevils found in eastern North America; and summarize information on the biology, habits, food plants, and feeding damage of *I. virens* in its native range.

Initial Detection, Additional U.S. Records, and Specimen Deposition

The first specimens of *I. virens* were taken in pitfall traps on a farm near Robesonia (Heidelberg Twp.), Pennsylvania (Berks Co.) in May 1994. During 1994–1997, numerous additional specimens of *I. virens* were collected in pitfall traps set in paddocks of grazed pastures of 5 other Pennsylvania counties. Other locality records, many from 1998 and 1999, have become available for Connecticut, Delaware, Maryland, New York, New Jersey, Pennsylvania, and Virginia. The collection of specimens of *I. virens* from Connecticut, Maryland, and Virginia was the direct result of those states' Cooperative Agricultural Pest Survey-Eastern Region (CAPS) activities for 1999. All known eastern U.S. collections of *I. virens* (mostly by pitfall trapping, and sweep-net or vacuum sampling) are listed below and mapped in Fig. 1.

CONNECTICUT: *Litchfield Co.,* East Canaan, 15-VI-1999; Norfolk, 15-VI-1999. DELAWARE: *New Castle Co.,* Newark, 21 & 22-IV-1998; Smyrna, 25-VII-1999. MARYLAND: *Cecil Co.,* Calvert, 22-IV-1999; Chesapeake City, 22-IV-1999; Conowingo, 22-IV-1999; Cowentown, Fair Hill NRMA, 22-IV-1999; Elkton, 22-IV-1999; Rising Sun, 22-IV-1999; Warwick, 22-IV-1999. *Harford Co.,* Dublin, 26-IV-1999. *Kent Co.,* Chestertown, 3-V-1999; Golts, 22-IV-1999; Kennedyville, 3-V-1999; Millington, 22-IV-1999. NEW JERSEY: *Hunterdon Co.,* Snyder research farm, 30-VI-1992 and 14 & 21-VII-1992; no precise locality, 3-X-1997. *Salem Co.,* Woodstown, 8-X-1997. *Warren Co.,* 6-X-1997. NEW YORK: *Chemung Co.,* Lowman, 16-VII-1997. *Chenango Co.,* Earlville, 15-VII-1997. *Orange Co.,* Westtown, 29-VII-1998. *Tompkins Co.,* Ithaca, 28-VII-1998. *Westchester Co.,* Yorktown Heights, 23-XII-1996. PENNSYLVANIA: *Berks Co.,* Robesonia, V-1994, 1996 and VII, IX-1996, 6-VI-1997. *Bucks Co.,* Quakertown, 1-VI-1998; Nockamixon State Park, 1-VI-1998. *Carbon Co.,* Normal Square, 20-V-1998; Lehighton, 20-V-1998; Jim Thorpe, 20-V-1998. *Chester Co.,* Honey Brook, 30-VII-1997. *Columbia Co.,* Centralia, 8-VI-1998; Numidia, 8-VI-1998. *Cumberland Co.,* Carlisle, 14-VI-1999; Summerdale, 10-VII-1998. *Dauphin Co.,* Harrisburg, 18-V-1998. *Delaware Co.,* Swarthmore, 18-VI-1998. *Lancaster Co.,* Kirkwood, 28-VII-1997. *Lebanon Co.,* Myerstown, 6-VIII-1997. *Lehigh Co.,* Coopersburg, 1-VI-1998; Fogelsville, 7-VIII-1997. *Luzerne Co.,* Freeland, 20-VII-1998; Hazelton, 20-VII-1998; White Haven, 20-VII-1998. *Lycoming Co.,* Montgomery, 25-VI-1998. *Monroe Co.,* Appenzell, 7-VII-1998; Brodheadsville, 7-VII-1998; Saylorsburg, 7-VII-1998; Stroudsburg, 7-VII-1998. *Montgomery Co.,* W. of Boyertown, IX-1997. *Montour Co.,* Danville, 26-V-1998. *Northampton Co.,* Bethlehem, 1-VI-1998. *Northumberland Co.,* Dalmatia, 22-V-1998; Malta, 8-VI-1998. *Perry Co.,* Marysville, 27-VII-1998; Roseglen, 7-VI-1999. *Philadelphia Co.,* Philadelphia, Fairmont Park, 14-VII-1998. *Schuylkill Co.,* Lavelle, 8-VI-1998; Newtown, 18-V-1998; Pitman, 8-VI-1998; Schuylkill Haven, 18-V-1998. *York Co.,* Longlevel, 28-V-1998. VIRGINIA: *Loudoun Co.,* Rte. 15, nr. Gilberts Corner, 30-VI-1999.

The first specimens of *I. virens,* representing the initial detection of this Palearctic species in North America, were initially identified by ERH and later confirmed by MAAZ. Voucher specimens are deposited in collections of the following individual and institutions: Cornell University (Ithaca,

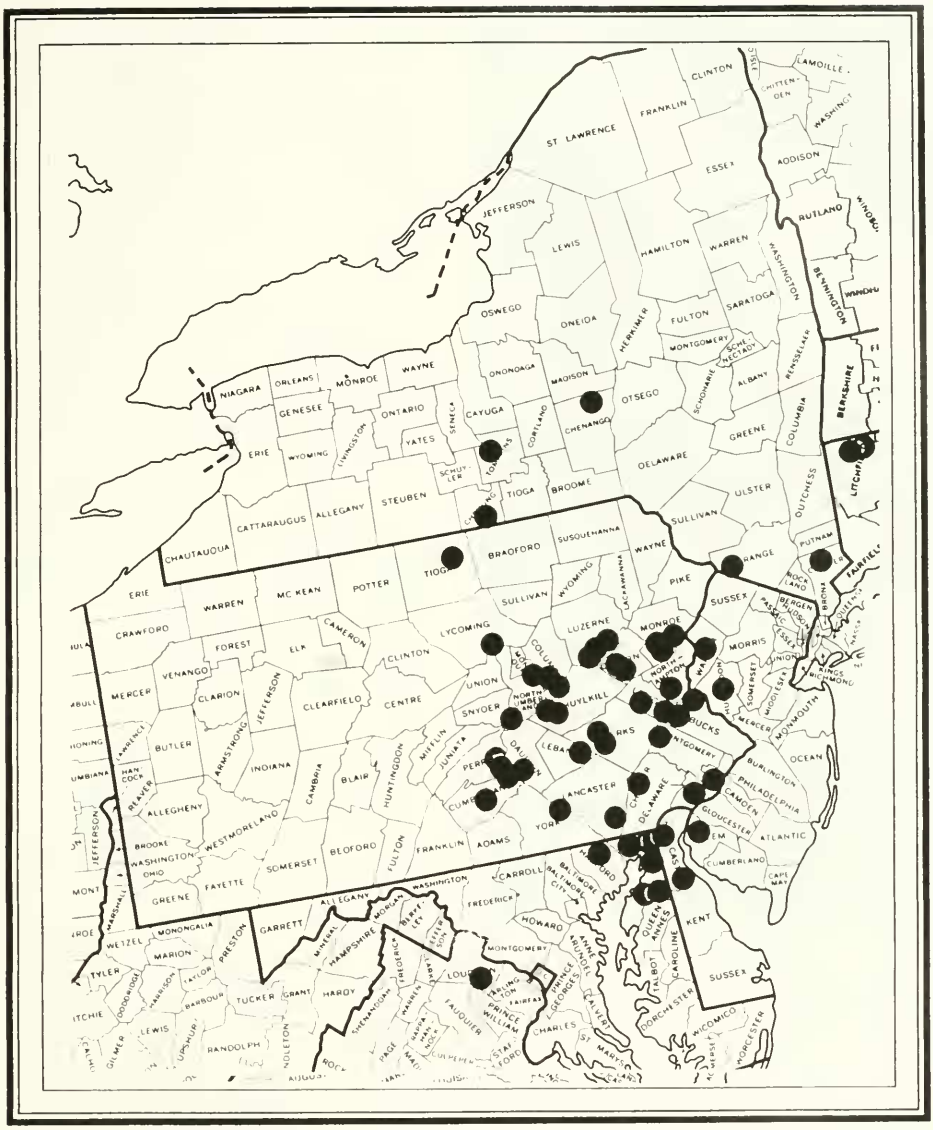
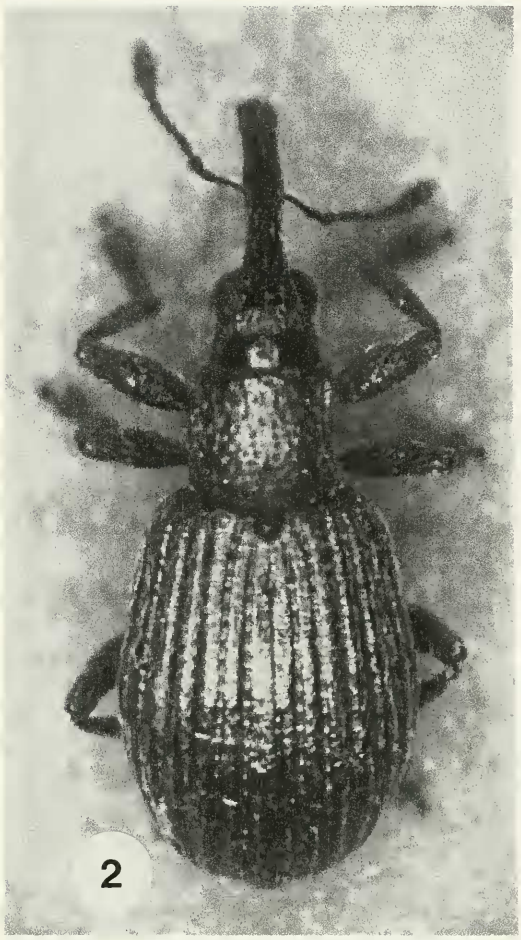


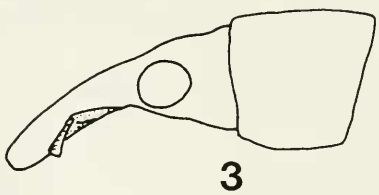
Fig. 1. Known geographic range of *Ischnopterapion virens* in the eastern United States.

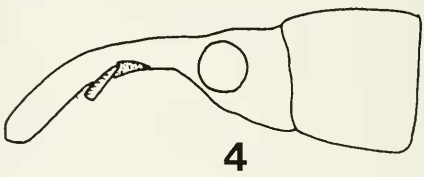
NY), USDA-Beneficial Insects Research Laboratory (Newark, DE), Pasture Systems and Watershed Management Research Laboratory (University Park, PA), Maryland Department of Agriculture (Annapolis), Pennsylvania Department of Agriculture (Harrisburg), Florida State Collection of Arthropods (Gainesville), Virginia Tech (Blacksburg), National Museum of Natural History, Smithsonian Institution (Washington, DC), University of Connecticut (Storrs), and Miguel A. Alonso-Zarazaga (Museo Nacional de Ciencias Naturales, Madrid, Spain).

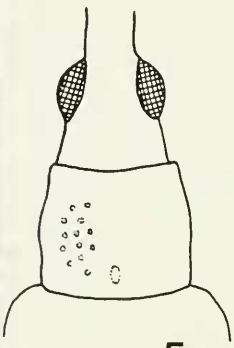
Native Geographic Range

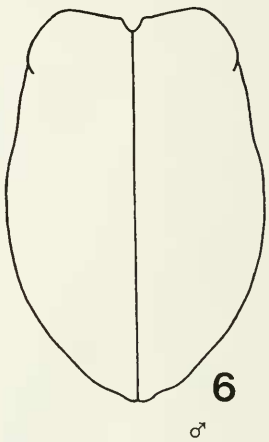
Ischnopterapion virens, widely distributed through most of the Palearctic Region, is common in temperate Europe and the Mediterranean subregion, including the Iberian Peninsula, and in the Nordic countries of northern Europe (Denmark, Finland, Nor-











Figs. 2–6. *Ischnopterapion virens*. 2, Adult, male, dorsal aspect. 3, Head and pronotum, male, lateral aspect. 4, Head and pronotum, female, lateral aspect. 5, Head and pronotum, male, dorsal aspect, showing punctation in part. 6, Elytra, male, dorsal aspect. Scale line for Fig. 2 = 0.5 mm. (Figs. 3–4 after Morris 1990; Figs. 5–6 after Gonget 1997.)

way, Sweden) (Gonget 1997). Occurring commonly and abundantly throughout England, Wales, Ireland, and locally in Scotland (Fowler 1891, Morris 1990), it is recorded also from Siberia, Syria, and northern Africa (Algeria) (Hoffmann 1958, Brito-Castro and Oromi-Masoliver 1986), and the Canary Islands (Tenerife and La Palma) (Brito-Castro and Oromi-Masoliver 1986).

Adult Redescription

The following redescription is adapted from Gonget (1997). Length 1.8–2.6 mm, oblong, slightly convex (Fig. 2). Body black, with aeneous or metallic greenish reflection, elytron distinctly metallic greenish or greenish-blue, shining, vestiture rather sparse. Male rostrum (Fig. 3) shorter, slightly curved, about 1¼ times as long as pronotum, pubescent at apex. Female rostrum (Fig. 4) longer, curved, about 1½ times as long as pronotum, pubescent only at base. Frons slightly convex, finely and sparsely punctured. Vertex finely and sparsely punctured apically and transversely striate and shining basally. Eye prominent, medium-sized to large and almost round. Pronotum (Fig. 5) broader than long, broadest behind

middle, slightly convex longitudinally, diffusely, finely and shallowly punctured. Basal fovea of pronotum (Fig. 5) rather distinct but short. Elytron (Fig. 6) oblong to elongate with sides rounded, broadest just behind middle, slightly convex longitudinally and somewhat depressed on disc, separately rounded at apex. Elytral striae moderately strongly punctured, first stria deeper on disc than others. Striae joined at apex as follows: 1+2+9, 3+4+7, and 5+8+6. Fine vestiture arranged in single row on each interstice, with one specialized seta at apical third of 7th interstice. Legs black with femora having greenish or bluish metallic reflection. Flight wings fully developed or rudimentary. Male genitalia illustrated by Alonso-Zarazaga (1990: 120).

Diagnosis

Ischnopterapion virens can be separated from the majority of North American apionine weevils by the following combination of characters: rostrum curved in both sexes, ventral surface of head with low subocular ridges, dorsal margin of scrobe not dentiform, prothorax moderately constricted behind middle, lacking basal flange, elytra apically neither expanded nor with deep pits, male metasternum lacks median tubercle near posterior margin, male tibiae without hooks (non-mucronate), legs dark, tarsal segments 1 longer than wide, tarsal segments 3 moderately large, strongly bilobed, tarsal claws with acute basal tooth.

Using these characters, in Kissinger's (1968) key to North and Central American apionid weevils, this newly detected species keys to couplet 27. It differs from the members of *Pseudapion sensu* Kissinger [*Apion disparatum* and *A. varicorne* species groups, most of the species transferred to genus *Kissingeria* by Alonso-Zarazaga (1990)] by the black legs and antennae (legs in part and/or antennae yellow in both groups of species in *Kissingeria*), only elytral interstria 7 with one specialized seta (one specialized seta on elytral interstria 7 and 9 in *Kissingeria*), striae at apex joining 7 with 3+4 and 8 with 5+6 (joining 7+8 in *Kissingeria*). It differs from *Apion panamense* Sharp (still placed in *Apion sensu lato*) by the shorter rostrum in both sexes, ca. 1.25 × length of pronotum in the male and ca. 1.50 in the female (ca. 1.42 in the male and ca. 1.70 in the female in *Apion panamense*) and by the latter having only one specialized seta on interstria 9. From the group of species assigned to *Ceratapion* by Kissinger (but not belonging to this genus, cf. Alonso-Zarazaga 1990) and which, being absent from his key, should key also to the same couplet, *I. virens* is distinguishable by the union of striae at the apex (as above), and the lack of a spine on the 1st mesotarsomere in the male (present in the so-called *Ceratapion*) and genital features.

Following the criteria explained in Alonso-Zarazaga (1990), *Kissingeria* and the so-called *Ceratapion sensu* Kissinger belong to the tribe Oxystomatini subtribe Trichapiina. *Ischnopterapion virens* belongs to the subtribe Synapiina of the same tribe, which includes three other Palearctic genera, not yet known to be in the Nearctic. The two subtribes formerly present in the Nearctic Region were: Trichapiina (including the large and heterogeneous genus *Trichapion* Wagner, *Kissingeria* Alonso-Zarazaga, and several species groups still placed in *Apion sensu lato,* which will probably need genera of their own after a thorough revision and study of their relationships) and Oxystomatina (represented in the Nearctic Region by two genera: *Mesotrichapion* Györffy (with the single species *Mesotrichapion* (*Loborhynchapion*) *cyanitinctum* (Fall)) and *Eutrichapion* Reitter, embracing three species in two different subgenera, *Eutrichapion s. str.* and *Leconteapion* Alonso-Zarazaga, namely: *Eutrichapion* (*Eutrichapion*) *viciae* (Paykull) (= *Apion alaskanum* Fall), *E.* (*Leconteapion*) *cavifrons* (LeConte) and *E.* (*L.*) *huron* (Fall). All the Nearctic members of Oxystomatina have a median tubercle on the male metasternum and key separately at couplet 13 in Kissinger's key. Even if the median tubercle in

these species is overlooked, members of *Eutrichapion* have black elytra and one specialized seta on interstriae 7 and 9, and members of *Mesotrichapion* subgenus *Loborhynchapion,* although having metallic elytra, have simple claws, the frons is striolate and the male mesorostrum is strongly lobed in dorsal view. In addition, *I. virens* is different from all these species by its first elytral stria being more deepened than the rest on the disc. *Mesotrichapion* (*L.*) *cyanitinctum* is recorded only from Manitoba and Quebec, and its host plant appears to be *Astragalus* (Fabaceae).

Host Plants and Damage

Plants of the family Fabaceae (= Leguminosae) are the principal hosts of adult and larval *I. virens,* with a decided preference shown for species of clover (*Trifolium*). These weevils are responsible for two types of feeding injury to clover: adults feed on the foliage (leaflets), whereas larvae feed or mine in the petioles, stems (stolons), root-crown, and possibly taproots.

Ischnopterapion virens larvae mine the stems of *Trifolium pratense* and generally bore downward towards the root-crown and roots during development (Stein 1965). In one instance, root damage was observed in red clover, *T. pratense* var. *spontaneum* (Stein 1965).

Adult feeding creates small (ca. 0.5 mm^2), elongate punctures in the leaf tissue (Wiech and Clements 1992: 438). Feeding sites vary depending on the age of the weevil. For example, newly emerged (first season) adults (in July) exhibit a preference for feeding on the apical portion of clover leaflets, while "older" adults (14–21 days minimum since emergence) use the basal portion of leaflets (see Stein 1965: 393, fig. 3). Adult feeding damage to white clover foliage is illustrated in Fig. 7.

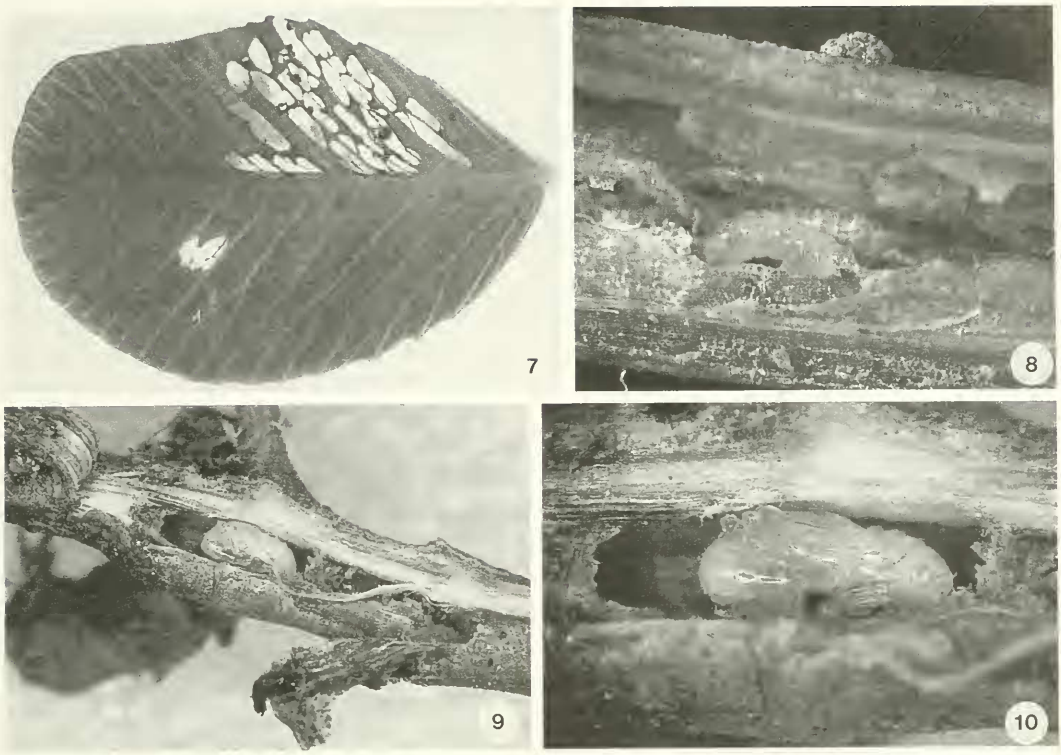
Although *I. virens* is generally considered to be a minor pest of clover crops in Europe (Balachowsky 1963), it can be a major pest causing significant damage. Because white clover (*T. repens*) is grown widely in mixture with grasses for animal feed, it is one of the most important herbage legumes in Britain (Wiech and Clements 1992). Chief among the invertebrates damaging white clover in southeastern England are apionine weevils, especially *I. virens* (Wiech and Clements 1992). In Bavaria in 1930 and 1931, a serious local and heavy infestation by *I. virens* occurred in red clover (*T. pratense*); larvae, by tunnelling in the taproot and root-crown, reduced plant growth so that fodder and seed yields were much decreased (Andersen 1932). In April and May 1926 in upper Austria, fields of red clover were heavily damaged by *I. virens,* with as much as 80% of this forage crop damaged (Werneck 1930).

The following species of *Trifolium* have been recorded as host plants of *I. virens: T. campestre* Schreb. (Brito-Castro and Oromi-Masoliver 1986); *T. pratense* L. (Fowler 1891, Werneck 1930, Markkula and Myllymaki 1957, Stein 1965, 1968); *T. alexandrinum* L. (Frauenfeld 1866, Delassus 1936, Dieckmann 1977); *T. arvense* L. (Hoffmann 1958); *T. incarnatum* L. and *T. fragiferum* L. (Dieckmann 1977); and *T. repens* L. (Dieckmann 1977, Stein 1968, Wiech and Clements 1992).

Biology, Seasonal History, and Habitat

The following account of the biology and seasonal history of *I. virens* is a summary drawn from field and laboratory observations of various investigators: Werneck (1930), Andersen (1932), Bovien and Jorgensen (1934, 1936), Markkula and Myllymaki (1957, 1958), Kokorin (1964), Scherf (1964), and Stein (1965, 1968, 1972a, b). Detailed studies on the morphology, biology, seasonal history, and behavior of *I. virens* are provided by Stein (1965, 1968).

Adult weevils overwinter in the soil near host plants or among plant debris at the base of their hosts (*Trifolium* spp.) and reappear in the spring, generally as early as late February–early March. After weevils



Figs. 7–10. *Ischnopterapion virens*, adult and larval feeding damage to white clover and immature stages. 7, Adult feeding damage to white clover leaflet. 8, Larva tunneling in white clover stem. 9, Pupa exposed in white clover stem. 10, Pupa in white clover stem, enlarged.

emerge from their overwintering sites, intensive feeding begins, followed by a spring mating period, generally from April to June. Oviposition generally begins in mid-April to early May and continues into late May–early June. The female uses her mandibles to chew a cavity in the petiole or stem, lays a single egg, and seals off the egg cavity with a mixture of excrement and abdominal secretions, probably to protect the egg and to prevent its desiccation. After about 7–8 days, first-instar larvae hatch and chew long mines in the stems, mostly downward. Larvae move downward into the stem where actual feeding will begin (Fig. 8). After about four weeks, a larva completes its development and pupates in a cavity in the lower part of the clover stem (Figs. 9, 10), just under the epidermis, directly above the root. The pupal stage lasts about 7 days, and first generation adults emerge, harden and become fully colored in about 2–3 days. Preimaginal (egg, larval and pupal) development takes place from May through much of August. Adults emerge throughout the summer, but generally in July and August. Newly emerged weevils feed intensively on the leaves for about four weeks, followed again by a non-feeding period of about 40 days, and then a dispersal, or migratory phase. Adults fly mainly during late summer and autumn (August–November), with a lower temperature threshold of 10°C (Stein 1972a), after which they feed until the beginning of winter. Mating takes place in early to mid-autumn. Thus, there are two periods of mating, one in autumn and one in spring. During a weevil's lifespan, at least three feeding periods occur: one directly after adult emergence in summer, a second from September to the beginning of the overwinter-

ing period, and a third after the overwintering period in spring (Stein 1965). There is one generation annually.

Egg development requires approximately 8 days, with a range of 6–12 days (Stein 1968). Bovien and Jorgensen (1936) reported a range of 14–18 days for egg development. Three larval instars occur in *I. virens*. Larval development takes about 27–28 days (Stein 1968), whereas Bovien and Jorgensen (1936) noted that 28–30 days were necessary for larval development. The average duration from egg to the pupal stage is approximately 34 days, with little or no difference between males and females, and a range of 30–39 days. The average length of the pupal stage is 7 days. Adults can survive as long as 360 days. Under laboratory conditions, each mated female is capable of laying a maximum of 90 to 166 eggs; however, for the majority of beetles in the field the number is much less, approximately 40–45 eggs per female (Stein 1968).

The seasonality and habits of *I. virens* in the Old World vary according to the investigator. In upper Austria, for example, eggs are laid on the root-crown or stems of red clover, with first instar larvae found in September; early instars overwinter in the taproots, make their way into the heart of the plant in spring, and pupate in July (Werneck 1930). In Germany, larvae of *I. virens* live in the tap root or root collar and overwinter as adults in the soil (Andersen 1932). Based on laboratory rearings in Denmark, Bovien and Jorgensen (1934) found that field-collected adults laid eggs in May in the midribs of leaves, that eggs hatched in early June, and that larvae later mined in the leaf petioles, eventually penetrating into the roots of smaller plants, but continuing to feed in the stems of larger plants. Markkula and Myllymaki (1957) found that *I. virens* females oviposited in the stems of red clover from late May to early August.

Ischnopterapion virens is associated generally with its leguminous host plants on slopes, along roadsides, in coastal pastures and meadows, and in grassy fields and cultivated clover fields (Gonget 1997). In Britain, this weevil is found "in a wide variety of open and grassy biotopes, including sand dunes and agricultural land" (Morris 1990).

Sampling and Natural History Observations in Pennsylvania

To gain a better understanding of population numbers of *I. virens* at the original collection site in Robesonia (Heidelberg Twp.), PA, one of us (JFS) conducted a sampling regime of white and red clover.

Weekly, 1 m^2, vacuum samples, taken from April 1998 through mid-July 1999, have yielded adult weevils nearly constantly. Even during the winter months (December 1998 through March 1999), adults were taken in vacuum samples; the 1998–99 winter was unusually mild, with temperatures seldom falling below freezing and with little to no snow cover for the majority of this period. Numbers of adults taken in the weekly samples actually increased during the winter months, as compared to those collected during the dry, warm months of summer and early autumn of 1998. From the surprisingly high numbers taken weekly during the winter, the population climbed somewhat during the spring, until new generation adults began to emerge. At this point, sample sizes increased dramatically to a high of 180 adults from a 1 m^2 area on June 15, 1999. Winter and early spring sample numbers averaged ca. 32 adults/m^2. From the June 15 peak, the number of adults present in the weekly samples declined drastically to a low of 0 in the July 13, 1999 sample. The extreme drought of the 1999 summer has all but eliminated succulent host plant material in the sampling area. The July 13 sample is the first such sample to be devoid of adults since sampling began in April 1998.

On numerous occasions in 1998 and 1999, we have observed the feeding habits of larvae of *I. virens* on white and red clover at Robesonia, PA. Mature white clover plants spread by creeping, above ground,

prostrate stems (stolons) that also root at the nodes (Uva et al. 1997). On May 21, 1998, we (ERH, JFS) split open, by means of a razor-blade knife, many stems (stolons) of white clover plants growing adjacent to grazed pastures and found that the majority were mined by larvae of *I. virens* (Fig. 8). Cut plant stems with larvae were brought into the lab and adults were reared to confirm their identity. In addition to the discovery of many mature larvae, we also observed pupae (Figs. 9, 10) inside these stems (stolons).

Random observations of larval feeding in the stems of white clover revealed extensive consumption of plant tissue. Larvae feed upon the central, pithy areas of the lower prostrate stems (stolons). During peak larval incidence (late May to early June), many stolons exhibited evidence of feeding by larvae over the entire length of the stolon. In such instances, larvae were found at approximately 2.5 cm intervals over the length of the infested stolon, and those stolons with late-stage larvae and pupae were often in a state of semi-collapse, contained large areas of browned and dessicating tissue, and often exhibited small holes through the epidermis of the plant. On 26 May 1998, RAB found larvae and pupae in the stems of red clover and noted nearly 100% infestation of these plants, with many dying and browning stems.

In spite of extensive larval feeding damage to the stems (stolons) of white clover in grazed pastures at Robesonia, PA, these plants nonetheless appeared vigorous and healthy. In sharp contrast, the red clover plants appeared to be more heavily impacted by the larval feeding of *I. virens*, especially the above ground stems (RAB observations).

On white clover, adults feed mostly in interveinal areas of the foliage, producing oval to elongate-oval holes. In the summer of 1999, JFS attempted to quantify the leaf area fed upon in relation to the total leaf surface area, using computer imaging and measurement packages. Percentage of leaf surface devoured ranged from 0% to a high of 21.25%, and averaged 2.64% of leaf surface sampled during a 5 week period (samples collected weekly from June 15 through July 13, 1999).

The pest status of *I. virens* and its long-term impact on white and red clover in the eastern United States are equivocal and will remain so until further field studies are conducted.

Acknowledgments

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